The 6th Answer Set Programming Competition

Martin Gebser, Marco Maratea, Francesco Ricca

13th International Conference on Logic Programming and Non-monotonic Reasoning
Outline

1. The Sixth ASP Competition
2. Format and Setup
3. Participants and Results
The Sixth ASP Competition

An event back to the usual timeline

- One year after the FLoC Olympic Games
- Hosted by LPNMR
- Biennial event
The Sixth ASP Competition

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Goals

- Measure the progress of the state of the art in ASP solving
- Improve benchmarks suite for robust evaluation
- Study the behavior of different solving techniques
The 6th Competition Setting

Improvements on the format

- Basic design choices maintained
- Some important novelties
The 6th Competition Setting

Improvements on the format
- Basic design choices maintained
- Some important novelties

Competition Setting
- System competition only and modeling competition on site
- Benchmark classification based on language features
- Benchmarks from past editions
  → The best encodings from 2014
  → Updated instance sets
  → New “real-world” benchmarks
- New instance selection process
- Updated versions of solvers, and newcomers
Outline

1. The Sixth ASP Competition
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System Competition Format

Sub tracks based on language features

- **Track 1 (Basic)**  normal LP + simple built-ins
- **Track 2 (Advanced)**  + choices, aggregates, HCF disjunction, query
- **Track 3 (Optimization)**  + weak constraints
- **Track 4 (Unrestricted)**  + non-HCF disjunction

Two Categories

- Single-Processor (restricted to 1-CPU Core)
- Multi-Processor (up to 8-CPU Cores)
System Competition Format

Sub tracks based on language features

- **Track 1 (Basic)**  normal LP + simple built-ins
- **Track 2 (Advanced)** + choices, aggregates, HCF disjunction, query
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- **Track 4 (Unrestricted)** + non-HCF disjunction

Two Categories

- Single-Processor (restricted to 1-CPU Core)
- Multi-Processor (up to 8-CPU Cores)

Marathon ← **NEW!!**

- The best solver of each team
- Time limit extended by one order of magnitude
  - Assess solvers on hard instances
Setup

System Inputs

- Fixed input in ASP-Core-2
- Scripts run with fixed parameters
- Fixed encoding + instance from STD input

System Environment

- Debian Linux 64bit with Intel Xeon E5-4610v2 CPUs
- Time limits
  - Competition: 20 minutes
  - Marathon: 3 hours
- Memory Limit: 12 GB
- Multi-processor track: up to 8 cores (16 virtual CPUs)
Scoring

ASP Competition 2014 Scoring

- Consider number of solved instances for decision problems
- Rank solvers on optimization problems by solution quality
- Runtime for tiebreaking

Decision and Query Problems

\[
\text{Score}(\text{Solver}, \text{Problem}) = \#\text{Solved}(\text{Solver}) \times 5
\]

Optimization Problems

\[
\text{Score}(\text{Solver}, \text{Problem}) = \sum_{\text{Instances } I} \frac{\#\text{NotBetter}(\text{Solver}, I) \times 5}{\#\text{Participants}}
\]
The Sixth ASP Competition
Format and Setup
Participants and Results

Competition Format

Scoring

ASP Competition 2014 Scoring

• Consider number of solved instances for decision problems
• Rank solvers on optimization problems by solution quality
• Runtime for tiebreaking

Additional Criteria

• Problems are equally weighted up to 100 points each
• Incorrect answers: disqualification on per problem basis
• Final scores by summing over all problems
Benchmark Suite

Benchmarks from 2014

- Considered all the domains from 5th edition
- Selected the encoding variant that exhibited better performance in the 5th edition
- Updated instance sets for
  - Knight Tour with Holes, Stable Marriage,
  - Ricochet Robots, and Maximal Clique
- Hardness-based classification of instances
  - Inspired of SAT Competition
  - Exploiting best solvers from the 5th competition
  - Robust selection
## Benchmark Suite: Domains from past editions

<table>
<thead>
<tr>
<th>Domain</th>
<th>App</th>
<th>Problem</th>
<th>Encoding</th>
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<tbody>
<tr>
<td>Graph Colouring</td>
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<td>Knight Tour with Holes</td>
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<td>Visit-all</td>
<td>Decision</td>
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<td>Bottle Filling</td>
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<td>Graceful Graphs</td>
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<td>Permutation Pattern Matching</td>
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<td>Ricochet Robots</td>
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<td>Sokoban</td>
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<td>Weighted-Sequence Problem</td>
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<td>Strategic Companies</td>
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* Track #1
* Track #2
* Track #3
* Track #4
Benchmark Suite: New domains

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<td>Decision</td>
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<td>Consistent Query Answering</td>
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<td>√</td>
<td>Optimization</td>
<td>#3</td>
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<td>Steiner Tree</td>
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<td>Optimization</td>
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<td>System Synthesis</td>
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<td>Optimization</td>
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<td>Video Streaming</td>
<td>√</td>
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Benchmark Classification (1)

Run the three best solvers of 5th ASP Comp
- clasp, lp2normal+clasp, wasp1.5
- same setting as competition
- 40 min TO (twice the timeout)

Some numbers
- 32 domains
- 5058 instances
- about 212 days of execution
Benchmark Classification (2)

<table>
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<th>Classification</th>
<th>Description</th>
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<tr>
<td><strong>(non-groundable)</strong></td>
<td>Instances that could not be grounded by any top-performing system within the timeout.</td>
</tr>
<tr>
<td><strong>(very easy)</strong></td>
<td>Instances solved by all top-performing systems in less than 20 seconds.</td>
</tr>
<tr>
<td><strong>(easy)</strong></td>
<td>Instances solved by all top-performing systems in less than 2 minutes.</td>
</tr>
<tr>
<td><strong>(medium)</strong></td>
<td>Instances solved by all top-performing systems within the timeout.</td>
</tr>
<tr>
<td><strong>(hard)</strong></td>
<td>Instances solved by at least one among the top-performing systems within 40 minutes.</td>
</tr>
<tr>
<td><strong>(too hard)</strong></td>
<td>Instances that could not be solved (no solution produced in case of Optimization problems) by any of the top-performing systems within 40 minutes.</td>
</tr>
</tbody>
</table>
Instance Selection

Instance Selection (Criteria)

- 20 instances are included in each domain
- Exclude non-groundable instances
- Each class shall contribute 20% to each domain
- Discard domains mostly made of easy instances
- Balance satisfiable and unsatisfiable instances for decision
- Prefer satisfiable instances for optimization and query
- Random selection from each class + 20% totally random
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- **Selection implemented in ASP!!!!**
- **Random seed:** the concatenation of winning numbers in the EuroMillions lottery of 23rd June 2015
Selection Statistics

Benchmark Suite

- 28 selected problems
- 4 too easy/uneven problems discarded
  - BottleFillingProblem
  - HanoiTower
  - Solitaire
  - Weighted-SequenceProblem
- 88 non-groundable instances
  - 86 IncrementalScheduling
  - 2 Sokoban
- Statistics about old solvers
  - Can be used for measuring the improvement of the state of the art
Outline

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The competition featured 13 systems coming from three teams:

- **Aalto Team**, Aalto University (9 solvers):
  LP2SAT+LINGELING, LP2SAT+PLINGELING-MT, LP2ACYCASP+CLASP,
  LP2ACYCPB+CLASP, LP2ACYCSAT+CLASP, LP2ACYCSAT+GLUCOSE,
  LP2MIP, LP2MIP-MT, LP2NORMAL+CLASP

- **ME-ASP Team**, University of Genoa, University of Sassari, University of Calabria (1 solver):
  ME-ASP

- **Wasp Team**, University of Calabria (3 solvers):
  WASP, WASP+DLV, JWASP
Results: Multi Processor Track

- T1
- T2
- T3

Participants:
- Martin Gebser, Marco Maratea, Francesco Ricca
Results: Multi Processor Track

Ip2sat+plingeling-mt

Ip2mip-mt

T1
T2
T3
The Sixth ASP Competition
Format and Setup
Participants and Results

Results: Track 1 - Basic

T1 Results
Results: Track 1 - Basic

T1 Results

- me-asp
- lp2normal+clasp
- lp2acycasp+clasp
- lp2acycsat+clasp
- wasp+dlv
- wasp
- lp2acycpb+clasp
- lp2sat+lingeling
- lp2acycsat+glucose
- jwasp
- lp2mip
Results: Track 2 - Advanced

T2 Results

AS Search
Query
Results: Track 2 - Advanced

T2 Results

- me-asp
- wasp+dlv
- wasp
- lp2acycas+clasp
- lp2normal+clasp
- lp2acycsat+clasp
- lp2acycpb+clasp
- lp2sat+lingeling
- lp2acycsat+glucose
- jwasp
- lp2mip

Legend:
- AS Search
- Query
Results: Track 3 - Optimization

T3 Results

0 100 200 300 400 500 600 700 800
Results: Track 3 - Optimization

T3 Results

- lp2normal+clasp
- me-asp
- wasp+dlv
- wasp
- lp2acycas+clasp
- lp2acycsat+glucose
- lp2acycsat+clasp
- lp2acycpb+clasp
- jwasp
- lp2mip

Participants

- Martin Gebser
- Marco Maratea
- Francesco Ricca
Results: Track 4 - Unrestricted

T4 Results

- AS search
- Optimization
- Query

0 50 100 150 200 250 300 350 400
Results: Track 4 - Unrestricted

T4 Results

- wasp+dlv
- me-asp
- lp2normal+clasp
- wasp

Legend:
- AS search
- Optimization
- Query
Results: ASP Competition 2014 - Overall

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Participants and Results

The 6th Answer Set Programming Competition
Results: ASP Competition 2014 - Overall

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Legend: T1, T2, T3, T4, T4-Opt
The Sixth ASP Competition
Format and Setup
Participants and Results

Results: ASP Competition 2014 - Overall

Participants:
- Martin Gebser, Marco Maratea, Francesco Ricca

The 6th Answer Set Programming Competition
Results: ASP Competition 2014 - Overall

- **lp2acysat+clasp**: 290 T1, 430 T2, 384 overall
- **lp2acysat+glucose**: 240 T1, 330 T2, 407 overall
- **lp2acycpb+clasp**: 265 T1, 395 T2, 315 overall
- **jwasp**: 185 T1, 295 T2, 280 overall
- **lp2sat+lingeling**: 265 T1, 355 T2, 355 overall
- **lp2mip**: 125 T1, 40 T2, 255 overall

**Participants**

- Martin Gebser, Marco Maratea, Francesco Ricca
The Sixth ASP Competition
Format and Setup
Participants and Results

Results: ASP Competition 2014 - Overall

![Bar chart showing results for different ASP solvers and tasks]

- Participants: Martin Gebser, Marco Maratea, Francesco Ricca
- The 6th Answer Set Programming Competition
### Results: ASP Competition 2014 - Overall

<table>
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Legend: T1, T2, T3, T4, T4-Opt
The Sixth ASP Competition

Format and Setup

Participants and Results

Results: ASP Competition 2014 - Overall

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Results: ASP Competition 2014 - Overall

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<td>me-asp</td>
<td>340</td>
<td>675</td>
<td>643</td>
<td>215</td>
<td>97.5</td>
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<tr>
<td>wasp+dlv</td>
<td>285</td>
<td>665</td>
<td>642.5</td>
<td>250</td>
<td>95</td>
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<tr>
<td>lp2normal+clasp</td>
<td>325</td>
<td>455</td>
<td>685</td>
<td>195</td>
<td>100</td>
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<tr>
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<td>560</td>
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<td>135</td>
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<td>495</td>
<td>503.5</td>
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<td>407</td>
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<tr>
<td>lp2acycpb+clasp</td>
<td>265</td>
<td>395</td>
<td>315</td>
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<td>jwasp</td>
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<tr>
<td>lp2mip</td>
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<td>255</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Martin Gebser, Marco Maratea, Francesco Ricca

The 6th Answer Set Programming Competition
Results: Solved By Task

- me-asp: 212 solved, AS Search 108, Optimization 34
- wasp+dlv: 182 solved, AS Search 105, Optimization 58
- wasp: 178 solved, AS Search 105, Optimization 18
- lp2normal+clasp: 195 solved, AS Search 96, Optimization 99
- lp2acycasp+clasp: 162 solved, AS Search 51, Optimization 111
- lp2acysat+glucose: 114 solved, AS Search 69, Optimization 45
- lp2acysat+clasp: 144 solved, AS Search 36, Optimization 108
- lp2acycpb+clasp: 132 solved, AS Search 30, Optimization 102
- jwasp: 96 solved, AS Search 56, Optimization 40
- lp2sat+lingeling: 124 solved, AS Search 0, Optimization 124
- lp2mip: 33 solved, AS Search 45, Optimization 0
Results: Cactus Plot

- lp2normal+clasp
- wasp+dlv
- me-asp
Results: State of the art

- clasp2014
- lp2normal+clasp
- lp2normal2+clasp-2014
- wasp+dlv
- wasp1.5-2014
- me-asp

+171 <---> 198%
+35 <---> 114%
Participants and Results

Results: Marathon Track 1 - Basic

T1 Results

340 360 380 400 420 440 460

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The Sixth ASP Competition
Format and Setup
Participants and Results

Results: Marathon Track 1 - Basic

T1 Results

<table>
<thead>
<tr>
<th>System</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>me-asp</td>
<td>340</td>
</tr>
<tr>
<td>wasp+dlv</td>
<td>380</td>
</tr>
<tr>
<td>lp2normal+clasp</td>
<td>400</td>
</tr>
</tbody>
</table>
Results: Marathon Track 2 - Advanced

T2 Results

- AS Search
- Query

0  200  400  600  800  1000
Results: Marathon Track 2 - Advanced

![Bar chart showing results for different systems.]

- **wasp+dlv**: Blue bar for AS Search, red bar for Query.
- **me-asp**: Blue bar for AS Search, red bar for Query.
- **lp2normal+clasp**: Blue bar for AS Search.

**Graph Details**
- **X-axis**: 0 to 1000
- **Y-axis**: System names

**Legend**
- Blue: AS Search
- Red: Query
Results: Marathon Track 3 - Optimization

T3 Results

630 635 640 645 650 655 660 665 670 675 680 685
Results: Marathon Track 3 - Optimization

T3 Results

- wasp+dlv
- lp2normal+clasp
- me-asp
Results: Marathon Track 4 - Unrestricted

T4 Results

- AS Search
- Optimization
- Query
Results: Marathon Track 4 - Unrestricted

T4 Results

- wasp+dlv
- me-asp
- lp2normal+clasp

Legend:
- AS Search
- Optimization
- Query
Results: Marathon ASP Competition 2015 - Overall

The 6th Answer Set Programming Competition

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Results: Marathon ASP Competition 2015 - Overall

The 6th Answer Set Programming Competition

Participants

T1 T2 T3 T4 T4-Opt

lp2normal+clasp

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Overall</td>
<td>385</td>
<td>755</td>
<td>680</td>
</tr>
<tr>
<td></td>
<td>280</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Marathon</td>
<td>445</td>
<td>765</td>
<td>648.3</td>
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<tr>
<td></td>
<td>235</td>
<td>96.6</td>
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</tr>
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<td></td>
<td>380</td>
<td>610</td>
<td>661.6</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Results: Marathon ASP Competition 2015 - Overall

- **me-asp**
  - T1: 445
  - T2: 765
  - T3: 648.3
  - T4: 235
  - T4-Opt: 96.6

- **lp2normal+clasp**
  - T1: 380
  - T2: 610
  - T3: 661.6
  - T4: 200
  - T4-Opt: 100

Participants and Results

- Martin Gebser, Marco Maratea, Francesco Ricca
Results: Marathon ASP Competition 2015 - Overall

- **wasp+dlv**
  - T1: 385
  - T2: 755
  - T3: 680
  - T4: 280
  - T4-Opt: 100

- **me-asp**
  - T1: 445
  - T2: 765
  - T3: 648.3
  - T4: 235
  - T4-Opt: 96.6

- **lp2normal+clasp**
  - T1: 380
  - T2: 610
  - T3: 661.6
  - T4: 200
  - T4-Opt: 100

- Martin Gebser, Marco Maratea, Francesco Ricca

The 6th Answer Set Programming Competition
The Sixth ASP Competition
Format and Setup
Participants and Results

Results: Marathon Solved By Task

- **wasp+dlv**
  - AS Search: 224
  - Optimization: 124
  - Query: 60

- **me-asp**
  - AS Search: 251
  - Optimization: 120
  - Query: 38

- **lp2normal+clasp**
  - AS Search: 238
  - Optimization: 108
Results: Marathon Improvements

- **wasp+dlv**
  - Improvement: 63

- **me-asp**
  - Improvement: 55

- **lp2normal+clasp**
  - Improvement: 55

<table>
<thead>
<tr>
<th></th>
<th>lp2normal+clasp</th>
<th>me-asp</th>
<th>wasp+dlv</th>
</tr>
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<tbody>
<tr>
<td>Improvement</td>
<td>55</td>
<td>55</td>
<td>63</td>
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</table>
Results: Marathon Stats

<table>
<thead>
<tr>
<th></th>
<th>% Potential Improvement</th>
<th>% Total Improvement</th>
<th>% Solved of Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>lp2normal+clasp</td>
<td>36.6</td>
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<td>30.1</td>
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<td>9.8</td>
<td>27.8</td>
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<tr>
<td>wasp+dlv</td>
<td>37.7</td>
<td>11.3</td>
<td>29.9</td>
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</tbody>
</table>
The Sixth ASP Competition
Format and Setup
Participants and Results

Results: Marathon Cactus Plot

- lp2normal+clasp
- wasp+dlv
- me-asp

Participants:
- Martin Gebser
- Marco Maratea
- Francesco Ricca

The 6th Answer Set Programming Competition
Results: Memory usage

- **Avg Memory**
- **Memory OUTS**

The chart shows a comparison of memory usage across different systems, with noticeable variations in performance.
Results: Memory out by domain

- CombinedConfiguration
- CQA
- Nomistery
- StrategicCompanies
- Reachability
- PermutationPatternMatching
- IncrementalScheduling
- StableMarriage

Martin Gebser, Marco Maratea, Francesco Ricca
The 6th Answer Set Programming Competition
Results: Timeouts by Domain

- CombinedConfiguration: 180
- StableMarriage: 160
- IncrementalScheduling: 150
- PermutationPatternMatching: 120
- Nomistory: 100
- GracefulGraphs: 90
- Labyrinth: 80
- QualitativeSpatialReasoning: 70
- Sokoban: 60
- KnightTourWithHoles: 50
- PartnerUnits: 40
- RicochetRobots: 30
- Visit-all: 20
- GraphColouring: 10
- Reachability: 5
- StrategicCompanies: 2
- ComplexOptimizationOfAnswerSets: 1
- CQA: 0
## (Implemented) Suggestions from 2014 Event

### Simplify Output
- Unify output for tasks
- Reduce number of exit codes

### Instance Selection
- Process for discarding very easy/hard
- More ASP-oriented real-world applications
- Enforce classification by language features
- Non-ground and ground tracks?
- Cautious/Brave Reasoning?

### Modeling Competition
- Interactive event? Challenges? . . .
(Implemented) Suggestions from 2014 Event

Simplify Output
- Unify output for tasks ← DONE!
- Reduce number of exit codes ← DONE!

Instance Selection
- Process for discarding very easy/hard
- More ASP-oriented real-world applications
- Enforce classification by language features
- Non-ground and ground tracks?
- Cautious/Brave Reasoning?

Modeling Competition
- Interactive event? Challenges? . . .
## (Implemented) Suggestions from 2014 Event

### Simplify Output

- Unify output for tasks \(\leftarrow\) DONE!
- Reduce number of exit codes \(\leftarrow\) DONE!

### Instance Selection

- Process for discarding very easy/hard \(\leftarrow\) DONE!
- More ASP-oriented real-world applications \(\leftarrow\) DONE!
- Enforce classification by language features \(\leftarrow\) DONE!
- Non-ground and ground tracks?
- Cautious/Brave Reasoning?

### Modeling Competition

- Interactive event? Challenges? . . .
(Implemented) Suggestions from 2014 Event

Simplify Output
- Unify output for tasks ← DONE!
- Reduce number of exit codes ← DONE!

Instance Selection
- Process for discarding very easy/hard ← DONE!
- More ASP-oriented real-world applications ← DONE!
- Enforce classification by language features ← DONE!
- Non-ground and ground tracks? Need for more grounders!
- Cautious/Brave Reasoning? Brave reasoning is missing

Modeling Competition
- Interactive event? Challenges? . . . ideas?
### Suggestions for future ASP events (1)

#### Simplify Output
- Avoid using exit codes with custom semantics
  - Easy choice for SAT, not for ASP solver scripts!
- Embrace POSIX-compatible convention
  - Zero for success and non-zero for error

#### Scoring
- Less dependent on number of participants
- More emphasis on solved (optimal) solutions
  - 5 points is too much for non-optimal witnesses
- Two rankings?
Suggestions for future ASP events (2)

Benchmark Suite
- Maintain classification by hardness
- Don’t stop adding ASP-oriented real-world applications
- Maintain classification by language features
- Maintain some more easy domains

Reasoning Tasks
- Brave Reasoning
- Propositional program evaluation
- Tracks for extended language features
Suggestions for future ASP events (3)

Modeling Competition

- Keep it as it is... pure fun!
- Open to remote participation as LP/CP Contest at ICLP
- More advertisement

Extend the ASP Development community

- ASPLib web site
- Lower the entrance barrier
  - Emphasize winners of tracks...
- … ideas?
Thank you for your attention!
Thank you for your attention!

Award ceremony during the social dinner!